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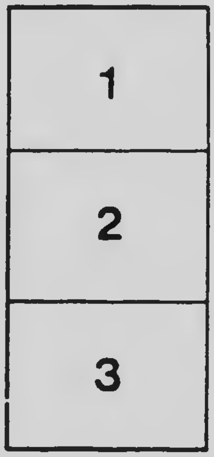

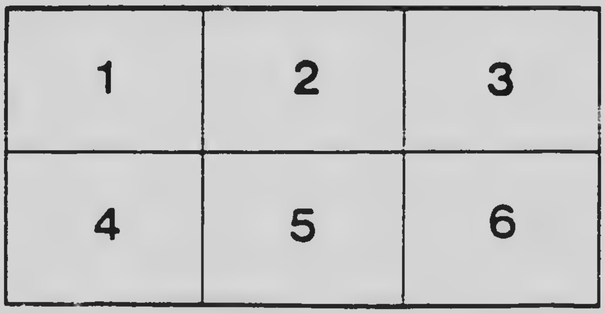

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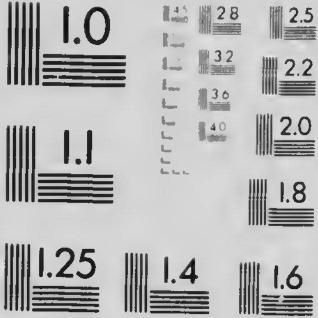

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Vol. I, No. 18

ORBIT OF THE SPECTROSCOPIC BINARY H. R. 6169

BY REYNOLD K. YOUNG

H. R. 6169 (R. A. 1900, $16^h\ 30{\cdot}9^m$, $\delta = +17°\ 15'$) was announced as a binary in 1919 by the writer from 4 single-prism plates. These spectra showed a range of about 60 kilometers and the lines looked fairly sharp. Thirty-eight additional observations have been secured with a view to determining the orbital elements. On many of the later plates the secondary component is plainly visible though very much fainter than the primary, the ratio of intensities being about 3 to 1. When the lines are superimposed, the spectrum shows a fairly good Ao type spectrum, many of the iron lines, such as 4045, 4063, 4071 and other metallic lines being visible. At other times only the calcium line and the hydrogen series and magnesium 4481 could be measured. The magnesium line in the componer., pectrum seems to be weaker than the other lines for under all circumstances this line is fairly sharp.

The period was soon found to be approximately ten and one-half days and when the observations are plotted on a single revolution they show that the orbit is quite eccentric and that the observations of the two components are clearly resolved only on one-half of the orbit. The great difference in intensity of the two components makes the measures of the blend follow the orbit of the primary. In the solution for the elements all those observations which showed single lines were assigned to the primary curve and given smaller weight than those observations where the two spectra could be measured. Two plates taken near the crossing point but blended so as to make the lines diffuse were rejected entirely. The measures of the secondary were also included in the solution and given weights as indicated in the table of observations below. The columns are in order, the plate number, the date of observation and the Julian Day, the velocities obtained for components one and two, the number of lines measured and the weights assigned, the phase of the observation using the final period and finally the residuals which the final elements give for the observation. These were determined graphically.

OBSERVATIONS OF H. R. 6169

Plate	Date	Julian Date	Velocity		Lines	Wts	Phase from 2,422,420	Residuals	
			Comp. I	Comp. II				Comp. I	Comp. II
	1918								
285	July 1	2,421,776·753	+ 2·1		1		0·91	−15·0	
	1919								
1818	April 21	2,070·936	−31·2		6		9·98	+ 5·6	
2062	June 1	2,111·836	−56·6		4		8·64	−45·8	
2343	July 13	2,153·732	−28·8		4		8·29	+11·0	
	1920								
4012	April 5	2,420·906	− 6·6		4	0	0·906	−23·6	
4030	" 7	2,422·931	+17·5	−110·1	3-2	2-1	2·931	+ 1·5	−12
4050	" 9	2,424·877	−20·6		6	2	1·877	+ 8·8	
4069	" 10	2,425·970	−48·2		1	3	5·970	− 3·2	
4079	" 12	2,427·863	−45·2		2	2	7·863	− 1·2	
4091	" 13	2,428·963	−35·3		1	1	8·963	+ 2·9	
4145	" 23	2,438·905	−25·5	+51·1	7-1	3-0	8·345	+16·5	+ 7
4157	" 24	2,439·953	−28·3		2	2	9·393	+ 6·0	
4169	" 25	2,440·921	−49·0		7	3	10·362	− 0·4	
4188	" 30	2,445·887	−17·1		4	2	4·767	+ 9·6	
4196	May 1	2,446·925	−15·1		3	0	5·805	+24·9	
4208	" 2	2,447·906	−51·3	+44·8	2-4	2-4	6·786	− 9·5	− 2
4218	" 3	2,448·841	−45·4	+72·0	4-1	4-1	7·721	− 0·8	+ 5
4244	" 5	2,450·852	−19·2		8	3	9·732	+10·8	
4279	" 12	2,457·878	−34·6		3	2	6·198	+ 8·1	
4289	" 13	2,458·831	−33·1		2	2	7·451	+11·8	
4304	" 15	2,460·843	−28·6		6	2	9·133	+ 8·1	
4314	" 19	2,461·847	+63·8	−127·1	6-1	4-2	2·577	− 1·6	+ 9
4334	" 21	2,466·822	−26·8		9	3	4·582	− 3·0	
4343	" 21	2,469·758	−57·1	+ 33·2	4-1	3-1	7·518	−12·4	−15
4351	" 27	2,472·848			5	2	0·048	− 4·5	
4356	" 30	2,475·760	+41·2	−103·0	7-5	4-2	2·960	− 3·6	− 8
4368	" 31	2,476·779	−19·0		12	3	3·979	−11·0	
4393	June 2	2,478·810	−41·3		1	1	6·010	− 2·3	
4404	" 11	2,487·811	−23·3		11	2	1·451	− 3·0	
4419	" 17	2,493·795	−14·9		5	2	10·435	+ 2·0	
4428	" 18	2,494·778	−12·9		5	0	0·858	−27·9	
4435	" 19	2,495·843	+81·3	−143·4	5-3	4-2	1·923	+ 9·3	+ 2
4441	" 20	2,496·721	+52·2	−109·3	4-3	4-2	2·801	− 2·8	+ 5
4459	" 25	2,501·780	−53·6	+ 39·8	2-1	2-1	7·860	− 9·6	− 7
4480	" 28	2,504·748	−16·4		9	3	0·268	− 9·6	
4498	" 29	2,505·758	+12·3	−87·5	6-4	4-2	1·278	+ 5·5	− 2
4506	" 30	2,506·715	+73·7	−110·5	3-2	3-2	2·235	− 5·3	+15
4508	" 30	2,506·751	+87·0	−161·3	7-7	4-2	2·271	− 8·0	− 6
4511	" 30	2,506·814	+80·2	−169·2	7-6	4-2	2·334	+ 2·6	−17
4523	July 1	2,507·734	+20·7	− 82·5	5-3	4-2	3·251	− 4·3	−16
4656	" 24	2,527·767	+78·4	−151·6	6-5	4-2	2·167	− 0·9	+ 3
4740	" 31	2,537·787	+52·2	−120·5	8-7	4-2	1·627	− 5·7	+ 2

The early observations are very poorly situated for determining the period accurately. They are shown as solid circles on the radial velocity curve given at the end of the paper, and it can be seen that the last three have scarcely any weight while the first is near a crossing point. This observation has to be brought forward sixty-one revolutions. The observations in 1920 cover ten revolutions. If we shift the early observation forward to the other crossing point some of the latter observations would be shifted backward nearly half a day and this is not permissible. Hence the early observation is assigned to its correct place and poorly situated as it is, it has more weight in determining the period than the observations in 1920. After allowing for the probable effect of blending the period was fixed at 10·56 days and not included in the least squares solution.

The observations were grouped into the following normal places and preliminary elements selected.

NORMAL PLACES

No.	Phase from J.D. 2,422,120·0	Velocity	No. of Plates	Weight	O − C Preliminary.	O − C Final	pv^2 Prelim	pv^2 Final
1	0·092	16·3	3	·875	− 3·68	− 3·88	12	13
2	1·627	+ 52·2	1	·5	+ 2·17	+ 5·66	2	16
3	1·278	+ 42·3	1	·5	− 9·91	− 5·69	50	16
4	1·923	+ 81·3	1	·5	+ 5·21	+ 7·86	14	31
5	2·253	+ 80·8	4	1·875	+ 3·48	+ 1·76	21	6
6	2·689	+ 58·0	2	1·00	+ 1·51	− 3·34	2	11
7	2·951	+ 43·3	2	·75	+ 3·48	− 0·73	9	0
8	3·251	+ 20·7	1	·5	1·38	− 4·09	1	8
9	4·490	− 21·7	12	1·500	− 0·32	+ 0·72	1	1
10	6·058	− 13·0	3	·75	− 2·71	− 1·12	5	2
11	6·970	− 43·9	2	·5	+ 0·73	+ 1·41	0	1
12	7·852	− 41·8	5	1·75	− 0·23	− 0·08	0	0
13	9·202	− 29·8	3	·625	+ 7·45	+ 6·91	35	30
14	10·047	− 19·1	2	·75	+ 7·05	+ 6·43	38	31
15	1·627	−120·5	1	·25	+ 0·85	− 2·07	0	1
16	1·278	− 87·5	1	·25	+ 2·64	− 0·56	2	0
17	1·923	−143·1	1	·25	+ 1·79	+ 1·80	1	1
18	2·252	−155·6	4	1·00	− 8·35	− 1·31	70	2
19	2·689	−118·4	2	·5	− 4·17	+ 7·11	8	26
20	2·951	−105·4	2	·375	−17·54	− 7·97	115	24
21	3·251	− 82·5	1	·25	−22·46	−16·32	128	66
22	7·471	+ 42·5	1	·5	− 3·70	− 5·31	7	11

PRELIMINARY ELEMENTS

Period	$P = 10·56$ days
Eccentricity	$e = 0·43$
Longitude of periastron	$\omega = 0$ and 180
Semi-amplitude	$K = 62$ km. and 98 km.
Velocity of system	$\gamma = +17$ km.
Periastron passage	$T =$ J.D. 2,422,422·112

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The preliminary elements leave the residuals listed in the table of normal places under the heading O−C preliminary. Σpv^2 for the primary component is 190 and for the secondary 331. Observation equations were next formed, both K_1 and K_2 being combined in the same solution as separate unknowns.

OBSERVATION EQUATIONS

1	1·000x	− ·078y		− ·433u	+ ·545v	− ·343w	+ 3·68 = 0
2	1·000	+ ·803		− ·791	+ ·575	− ·771	− 2·17
3	1·000	+ 1·158		− ·209	+ ·425	− ·733	+ 9·94
4	1·000	+ 1·383		+ ·151	+ ·188	− ·374	− 5·21
5	1·000	+ 1·403		+ ·523	− ·143	+ ·287	− 3·48
6	1·000	+ 1·067		− ·408	− ·478	+ ·776	− 1·51
7	1·000	+ ·798		− ·800	− ·877	+ ·773	− 3·48
8	1·000	+ ·512		− ·918	− ·618	+ ·662	+ 1·38
9	1·000	− ·189		− ·195	− ·487	+ ·263	+ 0·32
10	1·000	− ·491		+ ·143	− ·236	+ ·086	+ 2·71
11	1·000	− ·564		+ ·605	− ·069	+ ·022	− 0·73
12	1·000	− ·563		+ ·603	+ ·075	− ·025	+ 0·23
13	1·000	− ·415		+ ·331	+ ·300	− ·117	− 7·45
14	1·000	− ·266		− ·018	+ ·445	− ·219	− 7·05
15	1·000		− ·803z	+ 1·255	− ·909	+ 1·224	− 0·85
16	1·000		− 1·156	+ ·330	− ·672	+ 1·159	− 2·64
17	1·000		− 1·383	− ·713	− ·298	+ ·592	− 1·79
18	1·000		− 1·403	− ·828	+ ·223	− ·450	+ 8·35
19	1·000		− 1·067	+ ·645	+ ·756	− 1·226	+ 4·17
20	1·000		− ·798	+ 1·264	+ ·911	− 1·222	+ 17·54
21	1·000		− ·512	+ 1·451	+ ·977	− 1·047	+ 22·66
22	1·000		+ ·570	− ·980	− ·021	+ ·007	+ 3·70

where $x = d\gamma$

$y = dK_1$

$z = dK_2$

$u = 100\ de$

$v = 100\ d\omega$

$$w = \frac{100\ \mu}{(1-e^2)^{\frac{3}{2}}}\ dT$$

From these we get the following normal equations

$15 \cdot 750x$	$+3 \cdot 758y$	$-2 \cdot 915z$	$+0 \cdot 487u$	$+0 \cdot 002v$	$+0 \cdot 137w$	$+10 \cdot 357 = 0$
	$+8 \cdot 520y$	$-0 \cdot 000z$	$-0 \cdot 824u$	$-0 \cdot 823v$	$+1 \cdot 232w$	$-9 \cdot 102 = 0$
		$+3 \cdot 979z$	$-0 \cdot 126u$	$-0 \cdot 640v$	$+1 \cdot 000w$	$-19 \cdot 480 = 0$
			$+6 \cdot 325u$	$+0 \cdot 983v$	$+1 \cdot 070w$	$+4 \cdot 437 = 0$
				$+3 \cdot 083v$	$-3 \cdot 625w$	$+16 \cdot 776 = 0$
					$+4 \cdot 908w$	$-27 \cdot 111 = 0$

and

$x = -0 \cdot 221$	$\pm 0 \cdot 85$	or $d\gamma$	$= -0 \cdot 22$
$y = +0 \cdot 408$	$\pm 1 \cdot 08$	dk_1	$= +0 \cdot 41$
$z = +3 \cdot 364$	$\pm 1 \cdot 64$	dK_2	$= +3 \cdot 36$
$u = +0 \cdot 0197$	$\pm \cdot 012$	de	$= 0 \cdot 00020$
$v = +7 \cdot 1967$	$\pm 4 \cdot 65$	$d\omega$	$= 4^\circ \cdot 12$
$w = +10 \cdot 064$	$\pm 3 \cdot 73$	dT	$= 0 \cdot 124$ day

so that the final elements with their probable errors become

Period	$P =$	$10 \cdot 56$ days	$\pm \cdot 005$ estimated
Eccentricity	$e =$	$0 \cdot 430$	$\pm \cdot 012$
Longitude of periastron	$\omega_1 =$	$4^\circ \cdot 12$	$\pm 2^\circ \cdot 66$
" "	$\omega_2 =$	$184^\circ \cdot 12$	$\pm 2^\circ \cdot 66$
Semi amplitude	$K_1 =$	$62 \cdot 41$ km.	$\pm 1 \cdot 08$ km.
" "	$K_2 =$	$101 \cdot 36$ km.	$\pm 1 \cdot 64$ km.
Velocity of system	$\gamma =$	$-9 \cdot 88$ km.	$\pm 0 \cdot 85$ km.
Periastron passage	$T =$	J.D. 2,422,422·236	$\pm 0 \cdot 046$ days.

$a_1 \sin i = 8{,}180{,}000$ km.

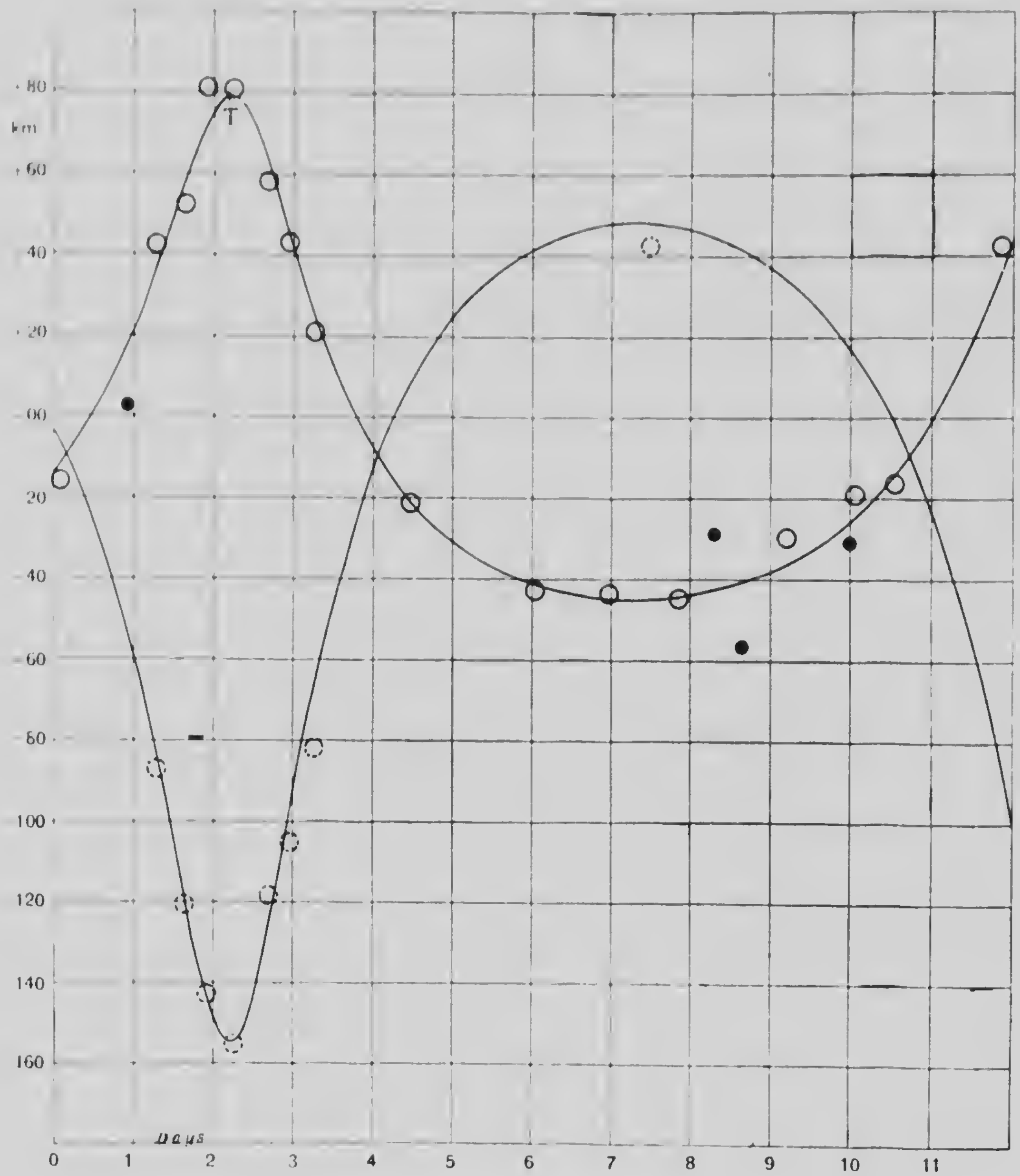
$a_2 \sin i = 13{,}280{,}000$ km.

$$\frac{m_2^3 \sin^3 i}{(m_1 + m_2)^2} = 0 \cdot 196$$

$m_1 \sin^3 i = 2 \cdot 19$

$m_2 \sin^3 i = 1 \cdot 35$

Σpv^2 was reduced to 166 for the primary and to 134 for the secondary while the probable error for a plate of average weight was $\pm 2 \cdot 9$ km. for the primary and $\pm 4 \cdot 3$ for the secondary.



Radial Velocity Curve of H.R. 6169.

Dominion Astrophysical Observatory,
Victoria, B.C
Sept. 1920.